Science, Technology, and Economic Growth: The Case of the Agricultural Experiment Station Scientist, 1975-1914

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Clichés of historical explanation are not always wrong, but they are never very useful. A familiar example of the species urges the importance of the relationship between science, technology, and economic development in the historical evolution of Western society. Can one object? The problem, of course, lies not in an unwillingness to concede this general point, but, given the present state of the art, in understanding this relationship in particular contexts and at particular times. Yet, despite its obvious importance, students of American society have devoted little attention to the historical interaction between science, technology, and social context; aside from a handful of case studies, the historical literature is spotty and unsystematic.

The following pages outline such a case study. Its central theme is the behavior of scientists and scientist-administrators within an institutional context defined by social and economic factors. More specifically, this is a study of the scientists employed by American agricultural experiment stations between the 1870s and 1914. In the hope of imposing some order upon a complex story, I will first briefly outline the nature of lay expectations—a primary dimension of the scientist's reality—then characterize the response of scientists to what was originally a far from satisfactory work situation;[1] the final pages argue that the experiment station scientist's efforts to shape a professionally satisfactory environment served as a component of economic and institutional change.

In 1875 the state of Connecticut established an agricultural experiment station. A dozen years later the federal government made the experiment

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1. The pressure of an aggressive lay constituency seemed particularly intolerable in a period during which ambitious young scientists were increasingly influenced by the German research ideal. The intellectual and behavioral demands of the several scientific disciplines made it difficult for the scientist who defined his aspirations in disciplinary terms to accept the constraints of an institutional context dominated by the economic needs and social preconceptions of this lay constituency.

station a national institution by providing in the Hatch Act $15,000 a year for the support of a station in each state.[2] The motivations of the state and national legislators who approved these measures seem transparent enough. These subventions for research were concessions to farm power in the form of a pork-barrel issue easily clothed in the neutrality of science and justified in terms of the traditional virtues granted the yeoman cultivators of the nation's farms. The stations would help the farmers adjust to an increasingly competitive world market, would rationalize and systematize his operations—would provide, that is, a conservative alternative to Socialist or Farmer's Alliance schemes for adjusting to changed economic and demographic realities.

Although the desire of politicians and farm spokesmen for scientific aid was real enough, their conception of the scientist's role was dismayingly imprecise. Professional scientists had since the 1850s been leaders in a campaign of "education" and agitation in favor of the experiment station idea, but they had found it both difficult and impolitic to be quite candid in their predictions of what an experiment station might be and do.

To many interested farmers and journalists, on the other hand, the role of the experiment station seemed all too clear; it was to perform the experiments which the individual farmer lacking time and opportunity could not; common sense, order, and precision allied with the American's native ingenuity were qualities adequate to the task. This was stated explicitly even in the writings of farm journalists and legislators enthusiastic in support of the experiment station movement.[3] A goodly proportion of the stations' lay advocates as well as their self-appointed critics expected—even into the twentieth century—that the experiment station would be operated as a model farm, indeed a model farm which would show a profit on its operations. (How, after all, could it be presumed a model if it lost money?) Up through World War I, experiment station workers had to answer the criticisms of visitors who could not understand why a stand of wheat might be dwarfed or why scores of horticultural varieties were not be be seen in vigorous profusion.[4]

2. The best general history of agricultural research in the United States is still A. C. True, *A History of Agricultural Experimentation and Research in the United States 1607–1925*, USDA, Misc. Pub. 251 (Washington, D.C., 1937). More recent and quite useful, though concerned largely with the history of formal policy discussion, is H. C. Knoblauch, E. M. Law, and W. P. Meyer, *State Agricultural Experiment Stations. A History of Research Policy and Procedure*, USDA, Misc. Pub. 904 (Washington, D. C., 1962).

3. "The average farmer," as the *Rural New Yorker* editorialized in 1886, "cannot afford to experiment in a careful systematic way for himself. Hence the value of Experiment Stations, if only they be conducted by intelligent, earnest, practical men" (vol. 45, 21 August 1886, p. 548).

4. As one dean explained in 1897: "The entire area is covered with experimental crops. We deem it unnecessary to demonstrate that farming may be made to pay, or that under bad management it is a failure" (E. Davenport to A. C. Bird, 11 October 1897, Dean's Letterbooks, Record Series 8/1/1, College of Agriculture, University of Illinois Archives). Cf. R. W. Thatcher to A. R. Dimond, 13 March 1910, Biochemistry Department Papers, Folder 58, University of Minnesota Archives. Such conceptions had a long and tenacious history. J. B. Turner, for example, a putative father of the land-grant college, argued in his 1848 plan for an industrial university that the professor of agriculture should be judged by his ability to plan experiments in which no money would be lost. "I would put no public funds into the professor's hands (certainly none beyond the original outfit) to squander in any day dreaming or absurd speculations. I would have every new experiment bear directly on his own private purse" (J. B. Turner to Jonathan Blanchard [1848], Turner Papers, Illinois Historical Survey).

Only with respect to chemistry did the "intelligent farmer" assume that special training might be a prerequisite for the experiment station staff member. Indeed, to many Americans agricultural science *was* chemistry; the name and doctrines of Liebig were by the late 1840s familiar in comparatively remote farm communities. But, even with respect to chemistry, the experiment station scientist found that assumptions underlying the expectations of his farm constituency implied career problems. One difficulty was the popular illusion that simple testing procedures could ensure soil fertility; once missing constituents were identified in the test tube, the farmer need only apply the prescribed fertilizer—and a marginal farm would become a source of profit. Throughout the last decades of the nineteenth and even into the twentieth century, farmers confidently sent in samples of soil for analysis and requested individually tailored advice in purchasing fertilizers.

The marketing of chemical fertilizers provided the occasion for another ambiguity which faced the first generation of station scientists. Perhaps the most telling single argument for the creation of experiment stations in the late 1870s and 1880s lay in their potential for regulating the composition of chemical fertilizers. Station supporters in older farming areas, conscious of competition from newer and more fertile states and indignant at the sometimes casual ethics of fertilizer manufacturers and dealers, assumed that experiment stations would act as "fertilizer control" agencies. (The North Carolina and Maine stations actually bore this designation as part of their formal title.) Experiment station advocates were willing enough to cater to these desires, as they were a source of leverage in gaining the support of influential farm and business leaders. Yet once the stations were established the young chemists who staffed their laboratories often found themselves prisoners of a deadening routine of fertilizer analysis.[5] In general, indeed, the functions of research and development were never clearly distinguished in the public mind from those of regulation and inspection.

In addition to the sharp consciousness of economic need and the vagueness of lay expectations in regard to science, other more general ideological factors played a role in shaping the experiment station scientist's environment. Perhaps the most important factor in setting intellectual guidelines was the generally assumed and morally absolute vision of an intelligent and prosperous yeomanry as a necessary basis for an enduring democracy. Clearly the personal aspirations of station scientists were secondary to the well-being of this virtue-embodying class. Experiment station scientists in the years before World War I had thus to deal with a constituency aggressive in its rectitude and casual in its assumption of the right to enforce demands upon the performance of station scientists. Were those chemists and botanists not public servants?[6]

The station scientists not only faced arbitrary and inconsistent lay demands, but they were outside the established structure of administrative authority as

5. C. W. Dabney to Mrs. Dabney, 16 March [1881], Box 25, Dabney Papers, Southern Historical Collection, University of North Carolina, Chapel Hill; A. T. Neale to W. O. Atwater, 13 March 1882, 17 March 1884, Reel 1, Atwater Papers, Edgar Fahs Smith Collection, University of Pennsylvania, Originals at Wesleyan University, Middletown, Connecticut.

6. When, for example, the *Sacramento Record-Union* printed Hilgard's lectures without permission,

well. As scientists or scientist-administrators they were newcomers at the mercy of a not always sympathetic hierarchy of college presidents and faculties. (The Hatch Act which endowed the stations in 1887 required that they be part of the land-grant college, except in those states where an independent station already existed.) Imposed from above by federal fiat, yet at first unprotected by federal regulation and control, the station and its budget were at the mercy of existing—and almost always undercapitalized—academic administrations. To secure a responsive and appropriate context for scientific research—or even for the adoption and dissemination of empirical findings—power would have to be gained by the stations within each state's hierarchy of economic and political power and this power then utilized in the academic sphere as well.

Some of the problems faced by experiment station scientists were not peculiar to the stations, but were characteristic of the late-nineteenth-century American academic world generally. Most station scientists had college teaching assignments as well as station duties, and as professors they were expected to teach a multitude of courses for long hours at low wages. A combination of German, chemistry, and botany was not atypical—with certain "pastoral" duties assumed as well. Particularly frustrating, especially to that increasing number of American scientists exposed to the values of the European academic disciplines, was the universal assumption that research was not a part of the college professor's expected duties. Standards other than competence in one's field were still routinely applied; even chemists, for example, found religious criteria important in securing a college position.[7] Southern institutions demanded not only piety, but Democratic orthodoxy—and at salaries even lower than those offered in the North.[8]

An experiment station position implied, moreover, a number of peculiar problems in addition to those normally faced by American would-be scholars. Personality, for example, was an important consideration in hiring and firing,

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the newspaper's manager argued that such lectures were not Hilgard's private property: "He is paid a salary by the university in behalf of the people of the state of California, . . . I believe a student has the right to take these lectures . . . and furnish the same for publication" (W. H. Mills to Rev. J. H. Bonte, 30 January 1882, Box 7, Folder 167, Hilgard Papers, Bancroft Library, University of California).

7. For examples, cf. W. F. King to W. O. Atwater, 9 July 1881, Reel 1, Atwater Papers; Davenport Fisher to S. W. Johnson, S. W. Johnson typescripts, Biochemistry Dept., Connecticut Agricultural Experiment Station.

8. As late as 1889, for example, Texas hoped to hire a "competent analytical chemist" for $800–900 (Louis F. McInnis to William L. Broun, 27 April 1889, Broun Papers, Dept. of Archives, Auburn University). An applicant for a position as professor of natural history assured the president of the University of Kentucky that "Your last three requirements are perhaps the easiest met. I am a *Southerner*, intensely so, both by birth and education; a *democrat*, because I could be nothing else, since I was born of democratic parents, and in a democratic state, and nourished on democratic pabulum." The gentleman concluded wanly that he was a "passive" Methodist (W. B. Stark to J. K. Patterson, 6 May 1889, Patterson Papers, University of Kentucky Educational Archives). It was well known that southern institutions hesitated to hire northerners, while northerners felt great hesitancy in accepting southern positions. Cf. Erwin Frink Smith to W. A. Henry, 10 May 1886, Letter-Press book, 1883–6, E. F. Smith Papers, American Philosophical Society; S. H. Gage to W. Trelease, 3, 12 September 1881, William Trelease Papers, Collection of Regional History, Cornell University.

for all station workers were expected to be effective in contacts with farmers.[9] Another problem lay in the demand for regular publication; bulletins and annual reports had to make their appearance even if there was little or nothing in the way of original findings to fill them. And research plans reflected economic needs, not the training and aspirations of staff members. If, let us say, no entomologist were available, a chemist or botanist would simply have to make do—answering farmers' questions, preparing bulletins, perhaps giving spraying demonstrations. Vacations had often to be sacrificed to rural lecture tours. In some states, moreover, days were filled with the endless detail of regulatory work, not only fertilizer testing, but the testing of seeds, horticultural varieties and the like.

No problem was more exasperating to station scientists than the assumption that they should be responsible for answering any and all questions which might be addressed to them. Indeed, a number of directors were proud to list among their accomplishments the fact that their stations had become "general bureaus of information." This achievement seemed far less positive to staff members increasingly occupied in answering a bewilderingly varied correspondence.[10]

With the exception of those stations created by states before the Hatch Act, the majority of stations were departments of the several land-grant colleges. And in this relationship still another ambiguity confronted the would-be scientist. Proximity to a university—though in some ways an intellectual stimulus—had drawbacks as well.[11] The most important, as we have implied, was the tendency of college and university administrators to exploit experiment station budgets. The most common form of such exploitation lay in charging the salaries of men whose duties were essentially teaching college science courses to the experiment station fund. Some administrators, however, showed a great deal more imagination, charging insurance, a portion of the president's salary, students' laboratory supplies—in one case even a carpet—to the Hatch fund. Professors of agriculture at land-grant colleges were in many cases appointed director of the new agricultural experiment station—at no increase in salary or reduction in teaching responsibilities. And, though administrators might demand a profit from farm

9. Thus, for example, Cornell felt some doubt in considering the promising young Alabaman Benjamin Duggar for an experiment station position because of some possible "southern peculiarity" which might interfere with his success in meeting New York farmers (George Atkinson to W. G. Farlow, 15 April 1896, Farlow Papers, Farlow Herbarium, Harvard University).

10. As one station scientist complained in 1881: "This is the *very busiest* time of the year for us. Farmers are busy making their plans for the coming year & they write to me on all sorts of subjects. And the trouble is every one has an equal right to an answer. I am a public man, and belong to the people & the people are relentless and exacting in their demands" (C. W. Dabney to Mrs. Dabney, Box 25, Dabney Papers).

11. One problem lay in the endemic status conflicts between scientists with station appointments—often in applied fields—and those in regular university departments. At Wisconsin, for example, the College of Letters and Sciences sought at one point to limit appointments in the College of Agriculture to men whose work lay exclusively in applied science. See W. D. Hoard to Charles Van Hise, 12 October 1908, and Van Hise to Hoard, 14 October 1908, Box 19, President's Papers, University Archives, University of Wisconsin. A half-year later, Hoard complained again to President Van Hise of "the ill-concealed sneers of certain professors in the faculty of the College of Letters and Science toward the College of Agriculture." Van Hise replied weakly that jokes about a "cow university" were not meant seriously. Hoard to Van Hise, 16 April 1909, and Van Hise to Hoard, 19 April 1909, Box 19, President's Papers.

operations, they ordinarily applied this income to general college purposes.[12] Not surprisingly, station scientists often opposed these practices which denied them time and resources for investigation.

The able and articulate among experiment station scientists and administrators had obviously to respond by seeking to restructure an environment which seemed on every hand to compromise their autonomy. Idealism as well as self-interest at once prompted and legitimated such policies. Few experiment station scientists could accept the possibility that an irreconcilable conflict might indeed exist between the scientist's needs and those of his agricultural constituency;[13] for none doubted that the conditions most appropriate for "high-grade" research were the optimum conditions for economic growth. A career in station work almost demanded such a point of view; the scientist's need to create a vis-à-vis between the demands of his own discipline and the requests of farm spokesmen made this formulation a logical and emotional necessity.

As I discuss the professionalization of station science in the following pages, I will be describing two principal social roles. One is that of the working scientist. Another and more specialized role is that of the research-entrepreneur—a role increasingly important in the twentieth century, but still novel in the formative years of the American experiment stations. These leaders—usually station directors—were forced to mediate between the world of science on the one hand and, on the other, the social and economic realities of a particular state constituency. The best of these research-entrepreneurs (who might or might not be productive scientists themselves) were able to forge political alliances of mutual convenience with farm leaders and businessmen. At the same time, however, they had to maintain some commitment to and understanding of the world of the scientific disciplines. That is, the successful research-entrepreneur had not only to tailor a research policy to the needs of his lay constituency, but still remain aware of professional values and realities, for institutional success was

12. For an example of the use of Hatch funds to pay insurance premiums, see A. C. True to R. H. Miller, 17 January 1897, Maryland File, Records of the Office of Experiment Stations, NA, RG 164; for the expenditures for dissecting material, see True to H. R. Clark, 5 April 1895, Oregon File, OES. "The average agricultural college trustee," one scientist commented after three years' experience under the Hatch Act, "believes that the government appropriation for experiment stations is a sort of windfall to the colleges, and is to be used to help these institutions" (*Agricultural Science* 4 [April 1890]: 102).

13. Some experiment station scientists did refuse to accept any version of this justifying doctrine, convinced that the incessant demands of the stations' agricultural constituency made any true scientific vocation impossible. As an example let me mention only the experiences of students of Harvard mycologist W. G. Farlow who, unable to secure "appropriate" university positions, became botanists and plant pathologists in experiment stations. The scorn of a man like Roland Thaxter for the Connecticut farmers who besieged him with demands for practical help was acid and unbending. ("Bordeaux mixture is the vilest compound imaginable," Thaxter complained to his teacher Farlow, "but it would give me intense satisfaction to spray a select committee of Connecticut farmers with it till they couldn't see out of their eyes and the moss started from their backs . . ." 14 April 1890, Farlow Papers; cf. Thaxter to Farlow, 4 March 1889, 31 December 1889, 13 March 1890, and W. C. Sturgis to Farlow, 29 March 1898, and 14 June 1900.) Other station scientists, oriented toward a "secular" careerism, used misleading rhetoric and political skills to achieve an at least temporary success. It should be emphasized that most station members filled a varied spectrum between the genteel scorn of a Thaxter and the unalloyed boosterism of certain other station men,

dependent not only upon the research-entrepreneur's political skills but upon his ability to recognize and hire men of talent and provide them with an at least minimally adequate environment.

Inevitably, so complex and demanding a role was pioneered successfully by only a handful of men. Inevitably as well, client-oriented policies which had brought success in the last decades of the nineteenth century became increasingly ambiguous as the twentieth century progressed. But the forging of this entrepreneurial role was still a necessary step in the development of the agricultural experiment station (as it was in the development of twentieth-century scientific institutions generally). I should like to suggest briefly how three such research-entrepreneurs, William A. Henry of Wisconsin, Eugene Davenport of Illinois, and Eugene W. Hilgard of California, sought and achieved institutional security. The parallels are, I think, obvious and instructive.

At the University of Wisconsin, the first formal provision for agricultural "experimentation" had been made two decades before the passage of the Hatch Act in 1887. An "experimental farm" had existed on the Madison campus since 1866, but it was not until the arrival of William A. Henry in 1880 that Wisconsin's agricultural program began to make progress.[14] Though a graduate of Cornell's four-year course in agriculture, Henry had had no further advanced training. Appointed as Professor of Agriculture, he realized immediately that it would be impossible to build institutional strength upon the college's teaching program; students simply failed to attend. "The other line of work left open to us is experimentation," he explained to the Board of Regents. "By advancing agricultural science and getting our farmers interested in our work, we can justly hope, I hope, for more prosperous days in the future."[15]

Henry's attitude toward the success of the station and college of agriculture was based on three policy assumptions. The first was a recognition of the necessity for improving relations with the state's influential farmers—and the conviction that this could be accomplished only through tailoring research to their needs and then convincing this skeptical farm constituency of the station's potential usefulness. Second, the realization that the ability to solve such problems could come only through the work of scientists with the best possible training. Third, the assumption that the success of both college and station would depend upon the ultimate success of Wisconsin's agricultural community in adjusting to a post-grain economy.

Not surprisingly, Henry's most strenuous efforts were directed toward the conversion of the state's wealthier and more influential farmers. He insisted that all his men, no matter what their personal inclinations, play an active role in

14. Board of Regents, University of Wisconsin, *Annual Report for the Year Ending September 30, 1866*, 8. The general history of the University of Wisconsin College of Agriculture has been well documented: W. H. Glover, *Farm and College. The College of Agriculture of the University of Wisconsin. A History* (Madison: University of Wisconsin, 1952); Vernon Carstensen, "The Genesis of an Agricultural Experiment Station," *Agricultural History* 34 (1960): 13–20; Edward H. Beardsley, *Harry L. Russell and Agricultural Science in Wisconsin* (Madison, Milwaukee, and London: University of Wisconsin, 1969).

15. "Report of the Professor in Charge of the Experimental Farm," Board of Regents, University of Wisconsin, *Annual Report for the Fiscal Year Ending September 30, 1882*, 44.

popularizing the station and college of agriculture. "I have a man I have been training for seven years," Henry explained, "and though he groans when he sees a visitor coming and feels like running, he knows he has got to stay and take it." Henry and his staff explained again and again to visitors that an experiment station demanded an excellent chemical laboratory, that it was not a model farm and could not be expected to make a profit. Henry reminisced,

> The first thing we are met with every day is this statement: "Well, professor, this farm will be satisfactory when you make it pay." . . . I knock that man right down and drag him off the farm. Some one says: "Professor, what does it cost you to make a pound of butter?" expecting me to say 15 or 18 cents, but I say, "Gentleman, most of our butter this winter is costing us $5 a pound, I think." I knock them right down at once and then explain. . . .[16]

In addition to such face-to-face contacts, Henry wrote widely for farm papers and lectured at Grange meetings and farmers' institutes throughout the state. He sought, in addition, to find ways of bringing farmers to Madison. In attaining this latter goal, Henry proved a vigorous educational innovator, pioneering the use of practical winter short-courses as a means of spreading the gospel of scientific agriculture and at the same time building support for the university.

Though interested in several areas of agricultural production, Henry chose to endorse dairying with particular vigor. By the middle of the 1880s, he had begun urging Wisconsin farmers to adopt dairying as a remunerative and stable response to a changing market.[17] When he hired S. M. Babcock as station chemist in 1887, it was because of the Göttingen-trained New Yorker's demonstrated success in milk chemistry. With Henry's talent for choosing first-rate investigators and his understanding of how such intellectual resources might best be applied in economic contexts, the Wisconsin station had by 1905 contributed a number of innovations instrumental in the reshaping of traditional dairy practice—the proper use of silage, cold curing of cheese, and the Babcock test, for example.

As a successful research-entrepreneur, Henry was blessed not only with an understanding of the economic needs of his state's agricultural community, but a measure of sympathy for the professional needs and attitudes of scientists. When hiring Babcock and dairy bacteriologist H. L. Russell—the latter a coworker of Babcock and Henry's successor as college dean and station director—Henry was careful to emphasize the light teaching duties and the opportunities for research which their positions implied.[18] And, though Wisconsin's presidents were generally friendly to his work, Henry discouraged even small encroachments upon research funds for general university purposes. By judicious cultivation of agricultural politicians and editors, and through an ability to produce

16. Remarks of W. A. Henry, Association of American Agricultural Colleges and Experiment Stations, *Proceedings of the Second Annual Convention . . . January 1, 2, and 3, 1889* (USDA, OES, Misc. Bull. 1 [Washington: G.P.O., 1889]), 37.
17. It should be noted that the Wisconsin State Dairyman's Association had sought to encourage scientific study of their industry's problems as early as 1875. Glover, *Farm and College*, 81. Eric E. Lampard's excellent study of Wisconsin's dairy industry clearly documents the role of the experiment station in its growth: *The Rise of the Dairy Industry in Wisconsin. A Study in Agricultural Change. 1820–1920* (Madison: State Historical Society of Wisconsin, 1963).
18. Henry to Babcock, 31 August, 16 September 1887, Babcock Papers.

tangible results, Henry and his successor H. L. Russell had by 1914 raised state appropriations for agricultural research to the then handsome figure of $75,000.[19]

This accumulation of institutional strength had certain negative concomitants. Perhaps most important was Henry's commitment to the need for "practicality" in research, a commitment justifiable perhaps in the 1880s but decreasingly fruitful in the first decade of the twentieth century. ("As between the co-called theorist and the practical man," he wrote just after leaving his administrative duties in 1908, "I would take the practical man every time.")[20] Henry could be a harsh taskmaster for those scientists unwilling or unable to commit themselves to agricultural improvement at the cost of sacrificing an opportunity for achievement within their particular discipline.[21] The heritage, moreover, of justification in terms of popular approval could handicap even the most creative laboratory men. Biochemist E. V. McCollum, for example, co-discoverer of Vitamin A, found it at first impossible to get financial support for the rat colony which he hoped to establish for nutrition studies; the Wisconsin legislature could hardly be expected to look with favor on tax monies being used to provide board and room for the farmer's bitter enemy.[22] Similarly, geneticists at Wisconsin and other stations anticipated opposition to plans for using small mammals—rats, mice, guinea pigs—in breeding experiments; why, critics asked, should state and national funds pay for information on the breeding of pests? Ultimately even more compromising was the heritage of extension work created by Henry's policy of attracting farm support through service. These politically strategic contacts with farmers had by the turn of the century produced an exhausting load of correspondence and lecturing.

The central irony lay, as we have seen, in Henry's very ability to gather statewide support. For the mechanisms which brought this success necessarily compromised the working scientist's autonomy. Yet, as contemporaries argued,

19. In 1914/1915, the University of Wisconsin College of Agriculture and Experiment Station expended $127,180 for research. The Adams and Hatch appropriations totalled $30,000, the state $75,456, and farm sales provided another $21,724. In addition, the state legislature provided $10,000 for the publication of experiment station bulletins and circulars (F. B. Morrison to J. H. Skinner, 28 March 1916, Box 12, College of Agriculture Papers, University of Wisconsin Archives). For an example of Henry's care to safeguard research funds, see Henry to Van Hise, 23 February 1907, Box 14, President's Papers, University of Wisconsin Archives.

20. Henry to Truman Fullenwider, 3 March 1908, Box 11, College of Agriculture Papers, University of Wisconsin Archives.

21. William Trelease, for example, though a fellow Cornellian, was restive under Henry's demands for practical performance (Trelease to W. G. Farlow, 22 June 1882, Farlow Papers). Agricultural chemist H. P. Armsby, not surprisingly, found himself "in hot water" on another occasion "for having talked sense in the butterine question" (Armsby to E. H. Jenkins, 20 July 1886, Incoming Correspondence, Director's Papers, Connecticut Agricultural Experiment Station, New Haven). Even S. M. Babcock, the "star" of Henry's staff, often found himself so distracted by visitors and short-course demands that he could not complete research projects (see Babcock to Mrs. Babcock 23 May 1897, 5 September 1897, 7 September 1899, Babcock Papers).

22. For a contemporary description of the harsh conditions in which McCollum worked, see L. B. Mendel to T. B. Osborne, 26 July 1912, Biochemistry Dept. Records, Connecticut Agricultural Experiment Station. For analyses of the background of nutrition work at the Wisconsin and Connecticut experiment stations, see Stanley L. Becker, "The Emergence of a Trace Nutrient Concept through Animal Experimentation" (unpublished doctoral diss., University of Wisconsin, 1968); Charles E. Rosenberg, "On the Study of American Biology and Medicine: Some Justifications," *Bulletin of the History of Medicine* 38 (1964): 37–75.

no other approach would have been appropriate to the social and political realities of the 1880s and 1890s. Henry's tactics were, indeed, so successful that administrators in a number of other states found in them a model for their own policies.

No research-entrepreneur was more assiduous in such efforts than Eugene Davenport, Henry's counterpart at the University of Illinois. Though perhaps less successful than Henry in promoting real contributions to agricultural productivity—possibly because he was less skillful in his choice of staff—Eugene Davenport was even more successful in garnering support for his research program. Agricultural education and research had borne comparatively little fruit at Illinois before Davenport was hired in 1895 as dean of the College of Agriculture.[23]

With feeble backing from a president uninterested in the college and station, Davenport was forced to turn for support to the state's agricultural producers and agriculture-related industries. A man of acute political sensitivity, he was quick to cultivate leaders in the state's specialized producers' associations, gaining legislative strength by having these representatives of the state's commercial agriculture lobby for categorical appropriations—for research in soils, in crops, in livestock, even in floriculture. "There is no question," Davenport explained again and again, "but that money devoted to investigation pays, and pays immediately." "In the final roundup before the legislature," he confided to an aspiring Iowa administrator, "nothing counts so much as a delegation of actual farmers representing organizations. Their influence does not depend upon their numbers; while anything like a popular movement, when organized, requires a good deal of work to arouse it in the first place, and is liable at any moment to subside." Ultimately, of course, Davenport realized, he would have to seek research funds without hemming them in with specific requirements.[24]

Ironically, however, his very success in building support for the college and station was to make the desired autonomy difficult to achieve. Even more than Henry, Davenport became the prisoner of his own political acumen. In administering the station, Davenport worked closely with advisory committees of prominent agriculturists to oversee the several lines of investigation the state had opted to support. (The Illinois Grain Dealers Association and Corn Grower's Association, for example, jointly appointed the committee on crops, the Illinois State Horticultural Society, the committee on orchards, the Dairyman's Association the committee on dairying, and so forth.) Enmeshed in so intimate a relationship, Davenport found it difficult to consistently maintain the initiative in the making of station research policy. In addition, farm leaders directly influenced

23. This interpretation of Davenport's work is based on the records of the Illinois College of Agriculture under Davenport's tenure as Dean and Director of the Experiment Station. Most important are the College of Agriculture Letterbooks, 1888–1911 (Record Series 8/1/1), Experiment Station Letterbooks, 1901–1904 (Record Series 8/2/2), and Agronomy Letterbooks, 1899–1919 (Record Series 8/6/3).

24. [Davenport], *The Work and Needs of the Agricultural College and Experiment Station of the University of Illinois, February, 1903* (n.p., n.d.), 12; Davenport to W. J. Kennedy, 1 February 1906, Dean's Letterbooks (Record Series 8/1/1); Davenport to C. F. Mills, 19 October 1900, Dean's Letterbooks.

hiring and firing, while large appropriations brought pressure for immediate results.[25]

Yet he could, by World War I, point to a record of outstanding growth for Illinois' College of Agriculture and Experiment Station. In terms of staff, research support, and number of students, the college and station had become firmly established. This is demonstrated vividly in Davenport's ability to bypass presidents James and Draper (neither of whom were enthusiastic advocates of agricultural education and research) in gaining access to the legislature;[26] Davenport was ultimately able to mobilize a network of state-wide influence in gaining support for general university needs; by 1910, the university's orphan child had become at once a leading advocate of and argument for legislative largesse.

Of our three examples, that of Eugene W. Hilgard of California is perhaps the most complex. For Hilgard was both scientist and research-entrepreneur, a geologist of international reputation and at the same time a gifted publicist and molder of public opinion.

When he arrived in Berkeley as Professor of Agriculture in 1875, Hilgard found a campus beset with problems; the Grange was actively hostile to an institution in which agriculture was clearly held in small regard.[27] Berkeley had failed as a college of agriculture, and Hilgard, like Henry and Davenport, turned to research as justification for continued legislative support. Hilgard immediately set out to placate the Grange through personal contacts and by undertaking work relevant to the needs of California agriculture, especially in viticulture—most notably his campaign against phylloxera—and, closer to his original interest and training, the study of California's varied soils. Central to these plans was an experiment station. (Even before arriving in Berkeley, Hilgard had sought to popularize the need for American agricultural experiment stations on the German model.) Within a few years of his arrival, Hilgard could boast of having created such a station, in function if not in name.[28] By the mid-1880s, Hilgard had built a respectable base of support for his work.

25. In 1911, for example, Davenport was forced by the state's dairy association to ask for the resignation of the head of his dairy husbandry department. Davenport to E. J. James, 11 April 1911, Dean's Letterbooks, Personal (Record Series 8/1/1). Such close relations between experiment station staff and their clients also maximized the likelihood of nonprofessional conduct; incidents of premature disclosure of work in progress—accompanied by grandiose claims—as well as staff members' involvement in indiscreet business enterprises all troubled Davenport's directorship.

26. As Davenport explained to a contemporary. "A man desiring to develop a department of economics or history, Greek or philosophy, is practically confined to internal conditions for the achievement of his ambition; fortunately it is not so with agriculture. The state of South Dakota, not the campus at Brooking, is your field. . . . If you can make your department indispensable to South Dakota, there is nothing you cannot have" (Davenport to A. N. Hume, 9 October 1913, File Drawer 6, Davenport Papers).

27. The following pages are based primarily on the papers of E. W. Hilgard at the Bancroft Library, University of California. For evaluations of Hilgard's principal scientific work, see: Hans Jenny, *E. W. Hilgard and the Birth of Modern Soil Science* (Pisa: Collana della Rivista "Agrochimica," *ca.* 1961); Maynard A. Amerine, "Hilgard and California Viticulture," ***Hilgardia*** **33** (1962): 1–23. See also Mary L. Mayfield, "The University of California Agricultural Experiment Station, 1868–1924" (unpublished Master's thesis, University of California, Davis, 1966).

28. Years later, Hilgard was happy to submit a claim for priority in establishing America's first experiment station (Hilgard to A. C. True, 7 January 1892, California File, OES).

The logic of Hilgard's position necessarily implied the legitimacy of an almost exclusive emphasis upon immediate economic goals; by the 1890s he was forced to defend his service-oriented policy against frequent criticisms from the Office of Experiment Stations and other would-be upgraders of station research. In an environment as novel as that presented by California, Hilgard argued, such policies were the only appropriate response. These were the arguments Hilgard employed, for example, in justifying to the Office of Experiment Stations his policy of encouraging branch stations throughout the state, a policy vigorously opposed by the OES. Hilgard was, moreover, forced to embrace an at-least-rhetorical unity with the working farmer and rancher. Despite his academic credentials, Hilgard assured farm audiences, he had had personal experience as a farm owner and understood their problems. He was not one of those professors who "fight shy" but one "who has been there and knows how it is himself." As a result of this responsiveness, however, Hilgard soon found that the demands made upon his time had become oppressive. "There is no rest here for anyone, wicked or otherwise," Hilgard complained to F. A. P. Barnard in 1886, "least of all for a man who, like myself, is in a position which authorizes everyone from the shock-haired and hayseed-bestrewn granger to the justices of the supreme court to ply me with questions on their private business." His routine correspondence alone, he complained, would "do credit to a wholesale business house."[29] But, as in Wisconsin and Illinois, such contacts were unavoidable if Hilgard's work was to find adequate support.

Like Davenport at Illinois, moreover, Hilgard had to contend with a President —and in California elements of the Board of Regents as well—unsympathetic to agriculture. As Dean of the College of Agriculture he had thus to wage a bitter biennial campaign for appropriations. Though generally successful in his lobbying efforts, Hilgard looked forward in the early 1880s with keen anticipation to the availability of permanent federal support for his state's experiment station; not surprisingly, he worked vigorously for passage of the Hatch Act. "I am getting heartily tired," he explained to a friend, "of my biennial fight for existence."[30] But even after passage of the Hatch Act he continued to lobby in Sacramento for the categorical appropriations which helped to insure the continued growth of his college and station. And Hilgard was justifiably proud of his achievements: "I have built up the whole," he explained to President George Atherton of Pennsylvania State University, "by an aggressive policy in the face of many discouragements, even the regents tolerating it at first only as a sop thrown to the Cerberus of the Grange. But the work has acquired an impetus that renders it unsafe for legislators or regents to ignore it."[31]

Differences in personality and local economic conditions implied minor tactical differences—but in all three cases the research-entrepreneur's strategy

29. Hilgard to F. A. P. Barnard, 1 January 1886, Hilgard Letterbooks, Hilgard Papers. For this bleak characterization of his correspondence, see Hilgard to A. L. Bancroft, 25 March 1886, Hilgard Letterbooks. Hilgard's avowal of empathy is taken from "Address to Agricultural and Horticultural Society," *Los Angeles Daily Republican*, 7 October 1877, clipping in folder 205, Box 9, Hilgard Papers.
30. Hilgard to Harvey Wiley, 29 July 1885, Hilgard Letterbooks.
31. Hilgard to G. W. Atherton, 6 December 1884, Hilgard Letterbooks.

was the same: the creation of institutional strength through alliance with members of the business, agricultural, and political communities. In terms of the scientist's immediate work environment, these relationships could, as we have suggested, become a mixed blessing. Even those laymen most sympathetic to the stations and most euphoric in their hopes for scientific agriculture often entertained quite narrow views of the tasks appropriate to the experiment station scientist.

Scientists reacted in several ways to such constraints. A principal response, as we have illustrated in the case of three states, was to work for power and thus autonomy within existing sources of economic and political influence. Another was to appeal to competing sources of power and reassurance, one the United States Department of Agriculture's Office of Experiment Stations, another—of a more general kind—the shared values of the several scientific disciplines. (These recourses were particularly important for scientists in states where deans and directors were more attentive to the demands of local clients than to the desires of their own staff members.) A third was the creation of new applied-science disciplines with norms more appropriate to the demands of the experiment station context than those of older pure-science fields. And, finally, agricultural scientists in almost every discipline reassured themselves and their clients by endorsing a rhetorical stance which emphasized the need for pure research if applied science was to prove ultimately fruitful.

The Office of Experiment Stations played a particularly strategic role in attempts by station scientists to shape their own professional lives. Under the control of men sympathetic to the scientist's point of view, the OES administration was consistently alert to the dangers of local obstructionism. In the 1890s the OES gained increased powers of audit and inspection, powers which it used to discourage the exploitation of Hatch funds.[32] (And such exploitation meant, it must be recalled, in day-to-day terms either the scientist's assignment to wearying teaching and extension work, or the diversion of funds which might have benefited research.) Functioning, moreover, as a semi-formal employment agency for workers in the agricultural and biological sciences, the OES was able to make tactful suggestions to the well-meaning, find jobs for innocent victims of local power conflicts, and better places for the competent. In the early years of the twentieth century, the elite among experiment station leaders united with the OES to lobby for passage of the Adams Act (1906), which doubled the funds available for the several state stations, but with the important and innovative proviso that the money be spent for "original investigation."[33]

32. Though the power to disallow claims was rarely invoked, the OES used the threat constantly, especially after it began the practice of making annual inspection trips to the several state stations. For a short account of the administrative history of the OES, see Milton Conover, *The Office of Experiment Stations, Its History, Activities and Organization* (Institute for Government Research, Service Monographs of the United States Government, No. 32, Baltimore, 1924). For an excellent brief evaluation of the OES and federal government–state station relations, see Leonard D. White, *The Republican Era: 1869–1901. A Study in Administrative History* (New York: Macmillan, 1958), 247–52.

33. For a detailed discussion of the background and passage of this measure, see Charles E. Rosenberg, "The Adams Act: Politics and the Cause of Scientific Research," *Agricultural History* 38 (1964): 1–10. The "original investigation" provision of the Adams Act provided greatly

Scientists also appealed to disciplinary peers for moral support and endorsement, and to such values as academic freedom and professional competence against local political or administrative pressures. Significantly, however, scientifically oriented station men also charged that certain administrators, in catering blindly to laymen, were performing a disservice to American agriculture as well as to freedom of inquiry. Such assumptions had become habitual by the turn of the century. For most American agricultural scientists had, as we have argued, adopted a rhetorical stance which justified science pure as a necessity if science applied was to function properly; only upon a base of high-quality research could ultimate economic gains be predicated. This assumption was a necessity for the great majority of station scientists—who could neither consider themselves mere implements of their agricultural constituency nor reject the structure of compromise exacted by this lay clientele.

Indeed this argument—with its corollary that *all* insights gained into the laws of nature would, through some serendipitous process, be transformed into immediate practical benefits—was so frequently reiterated that it became a source of unmet hopes and unreal expectations. Let me refer, by way of example, to the area of animal and plant breeding in the first dozen years of this century. The insights of Mendel and DeVries not only implied the creation of a new and promising discipline, but seemed almost to guarantee instant practical results. (One station writer noted slyly at the time that "Members of the legislature who have the dispensing of funds will certainly find more comfort in the theory of DeVries than in that of Darwin.")[34] Such ingenuous hopes were soon blighted; Mendel added little or nothing to the technical armamentarium of the skilled empirical breeder. As geneticist Raymond Pearl noted sharply before World War I, all that the new genetics had really done thus far was to help the breeder interpret his accustomed techniques. He explained,

> This may seem too mild a statement of the potential value of genetic science to the animal breeder. It undeniably does lack the grandeur of the vision sometimes opened out by the extension lecturer in his zeal to inspire the farmers to do better things, and at the same time pave the way for increased appropriations for his institution.[35]

The rhetorical emphasis upon the necessary and mutually beneficial relationship between science pure and applied did, however, begin to change at the end

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increased administrative leverage for the scientifically oriented administrators who controlled the OES. "[It] is an opportunity," one wrote at the time, "which has never been presented before in the world; and if embraced our stations may easily assume leadership in agricultural investigation . . . It will take a good deal of patience and arguing for lots of people think they are doing investigating work if they are conducting some variety tests or testing South Carolina rock against ground bone for potatoes" (E. W. Allen to J. B. Lindsey, 8 May 1906, Massachusetts File, OES).

34. N. E. Hansen, "Plant Breeding," Association of American Agricultural Colleges and Experiment Stations, *Proceedings of the Eighteenth Annual Convention . . . November 1–3, 1904* (USDA, OES Bull. 153 [Washington: G.P.O., 1905]), 119.

35. Raymond Pearl, *Modes of Research in Genetics* (New York: Macmillan, 1915), 169. Despite momentary embarrassments and gaucheries, this scientific entrepreneurship and the hopes upon which it fed helped create one of the institutional contexts in which academic genetics was to develop in this country. See Charles E. Rosenberg, "Factors in the Development of Genetics in the United States: Some Suggestions," *Journal of the History of Medicine* 22 (1967): 27–46.

of the nineteenth century. This accustomed emphasis became a subject of debate in a growing conflict between an older generation of scientist-administrators strongly committed to the legitimacy of the demands made by their agricultural clients, and younger—often European- or graduate-school-trained—laboratory men. These younger scientists tended to assume much higher ground in discrediting policies which allowed the perceived needs of a lay constituency to define research programs. As state support for stations increased in the early years of the century, and as the Adams fund became available after 1906, American experiment stations turned increasingly to the nation's doctoral programs for staff members. Agricultural colleges produced few doctorates and station directors had—in some cases unwillingly but with the consistent encouragement of the OES—to turn to basic science departments for well-trained men.[36] As their numbers increased, criticism of the older generation of politically sensitive research-entrepreneurs grew sharper and more frequent.

Reformers were willing to concede that accommodationism was necessary in the pioneer years of the experiment station movement; it was appropriate both to political realities and to the stations' limited technical capacities. But by 1900, articulate critics submitted, American agricultural research was ready to outgrow such immature relationships; it was no longer necessary to dramatize the possible relevance of station science to the farmer's economic needs. American scientists must now emulate their German counterparts and educate laymen and administrators to the need for higher standards of research if substantial increases in productivity were to be attained.[37]

It would be easy enough to emphasize ways in which the experiment station context and traditions played a negative role in the development of the sciences in America. A tradition of client-centered research led to much trivial and redundant work. The need to achieve institutional and individual autonomy did result in a habit of compromise—a habit easily justified by a democratically tinged rhetoric of service as ultimate goal.

Yet I think it can be argued that despite such constraints the agricultural experiment station played in sum a positive role in the development of the scientific disciplines in the United States. Though the relationship between agricultural scientists and the economic substrate which supported them was ambivalent, it served as a formative stage in the gradual shaping of a research

36. Within a few years, for example, of T. H. Morgan's first drosophila publications, Office of Experiment Station administrators were urging state directors to turn to the Morgan group at Columbia in their search for men to conduct breeding programs (E. W. Allen to H. W. Mumford, 2 January 1912, Illinois File, OES). However, a number of even the more alert and responsive members of the older generation of scientist-administrators felt real qualms in regard to hiring scientists with no specific farm training or orientation. See L. H. Bailey, "Training for Experimenters," *Agricultural Science* 5 (1891): 214–15; H. J. Waters to E. W. Allen, 24 March 1902, Missouri File, OES.

37. Probably the most articulate and dedicated of such spokesmen for the upgrading of station research was W. H. Jordan, Director of New York's Geneva Station. See, for example, his "Function and Efficiency of the Agricultural College," *Science* 34 (1911): 780–81.

context increasingly hospitable to more fundamental work.[38] Let me try to specify some components of this complex relationship.

One can begin with a positive generalization. The stations played a substantial role in the careers of individual scientists and in the formative periods of a number of the biological sciences in America—most prominently bacteriology, biochemistry, and genetics. The reasons are obvious enough. First, in years of austere academic budgets almost any position was a good one. A job moreover in which research and publication were formal aspects of one's duties seemed particularly attractive; though often disappointed, would-be scientists were again and again attracted to experiment station work. The better state stations and colleges of agriculture offered greater freedom than the United States Department of Agriculture,[39] while research positions in industry were still scarce indeed.

The most important direct relationship between the experiment stations and the development of the scientific disciplines in America lay, I feel, in the stations' role of strengthening the state universities. The strategies for accumulating political influence adopted by college and station interests had, as I have tried to illustrate, helped bring about a more secure level of support for many state universities; the relationship between college and station was essentially constructive—though as ambivalent and ambiguous as marriages generally. Examples of successful technological innovation had helped make investment in the production and dissemination of such innovation a plausible course of action—while at the same time creating a group of potential lobbyists in farmers and businessmen who had themselves benefited from station work. (And, of course, whatever role the stations played in increasing agricultural productivity ultimately increased the resources potentially available for expenditure on public purposes.)

Indeed, even though it may be argued that the relatively crude level of pre-World War I agricultural technology served to limit the stations' capacity for actually increasing productivity, the role of the experiment station in strengthening the state university—as at Wisconsin where such extremely strong departments as bacteriology, biochemistry, and genetics all grew up within the college

38. Analogous economic pressures helped as the twentieth century progressed to support a much closer and more organic relationship between basic science and agricultural technology. The comparatively rapid development of the scientific disciplines in the land-grant colleges and experiment stations surprised even contemporaries in the early years of this century. As Yale physiologist L. B. Mendel wrote after spending a week in Ithaca: "Incidentally my eyes were opened to the forces now enlisted in this country in the study of the branches of so-called agriculture. Many of us have certainly under-estimated the scientific possibilities of this movement" (Mendel to T. B. Osborne, Osborne Personal Boxes, No. 1, Biochemistry Department, Connecticut Agricultural Experiment Station).

39. William Bateson, for example, visiting the United States in 1907 was shocked at the inelegant circumstances of the American professoriate. "To be a University Professor without private fortune," he explained, "is the meanest kind of lot. They are slaved to death; also no time for original research. Hours unendurably long" (Bateson to Beatrice Bateson, 24 October 1907, Reel A, Bateson Papers, American Philosophical Society). For examples of skepticism toward the USDA's scientific bureaus, see J. W. Coulter to E. F. Smith, 14 July 1888, Smith Papers, A.P.S.; W. J. Spillman to A. F. Blakeslee, 1 November 1911, Blakeslee Papers, A.P.S.; H. J. Conn to K. F. Kellerman, 1 May 1911, Conn Papers, Collection of Regional History, Cornell University.

of agriculture and experiment station—became increasingly important as the twentieth century progressed and a more intricate and fruitful relationship between basic and applied science became both necessary and possible.[40] The experiment station with its professionally oriented staff of disseminators, adaptors, and innovators existed to provide a nexus in which such relationships could be created, exploited, and disseminated.[41]

At least as important, perhaps, as the direct role played by the stations in the development of American science was the effect they exerted upon economic growth and thus—inevitably—upon science as well. Obviously this distinction—that between the role of the stations in promoting economic growth and in the development of the scientific disciplines—is arbitrary at best. Yet granted the difficulty of evaluating specific inputs and relationships in a system so complex and interdependent, let me try to suggest in general terms some of the ways in which the existence of the stations and the consequent movement towards professionalization among station scientists served as a component of economic growth.

It is my contention that the gradual professionalization of the experiment station scientist constituted a specific input into the system of agricultural productivity. Put another way, the agricultural scientist's perception of an appropriate role and his efforts to narrow the gap between this ideal and his originally unsatisfactory circumstances altered his behavior and thus served as an agent of economic change. This influence was exerted in two general ways: in terms of innovation and adoption, and in the provision of mechanisms for the dissemination of knowledge.

Whether the experiment station scientist defined his role in terms of applied science or some more traditional discipline, conformity to a professional role implied publication; it meant mastery of a literature inexorably growing in both quantity and complexity—and, more fundamentally still, commitment to an acceptance by his fellow scientists as an ultimate measure of achievement. And such acceptance was defined with increasing circumstantiality in terms of knowledge and publication. Even the creation of new applied science disciplines —economic entomology, horticulture, or poultry husbandry, for example— was shaped by such general criteria as well as others more discipline-specific. In addition to the general values which we have discussed, agricultural scientists of all disciplines tended to accept service as an absolute value. In an era before the Smith-Lever Act, this ethic of Service helped (with the institutions' own need for ensuring public support) create an extension program in function if not in name, bringing and adapting agricultural innovation to an industry normally resistant to change.

40. The increasing success of the college of agriculture as an educational institution also played an important role in economic growth, helping create a consensus of values in farm leaders and thus conditions in which community receptivity toward innovation and respect for the role of science were maximized.

41. One might also discuss a number of tangible and permanently significant results of pre-World War I experiment station work—hybrid corn or the discovery of Vitamin A. Both, however, grew out of so complex a background that it is difficult to discuss briefly their relationship to economic context on one hand and the community of pure science on the other.

The political needs of the station scientists guaranteed that the educated, adequately capitalized farmer would be their natural ally in the achievement of power. Indeed, the larger the scale of an enterprise, the more likely it was—in general—to find experiment station scientists relevant. Innovation and adoption implied both capital and appropriate values. (And these values, education particularly, implied in their turn a degree of prosperity.) " I am sorry," W. A. Henry wrote in 1898, "to say that we have not accomplished much with the lower stratum of Wisconsin farmers, but the more intelligent ones who are leaders of their community and who help others by example, are for the most part strongly with us."[42] In inspection work or efforts at control, it was the less-educated general farmer who was often inhospitable to "book-farming" and to agricultural colleges which seemed remote from his needs and those of his children. Similarly, it was the small nurseryman or fertilizer manufacturer who frequently objected to station regulation, the larger producers who often welcomed it.[43] The experiment stations served with some efficacy to strengthen and rationalize—exacerbate if one likes—trends already apparent within American agriculture and society generally.

Logically enough, the stations tended to be most successful in states developing a specialized urban-market-oriented agriculture—and at the same time states in which respect for science and education as instrumentalities for economic progress and moral improvement was most apparent. With such a constituency eager to rationalize their methods—and capable of being convinced by station arguments and demonstrations—conditions for the interaction of the needs of station scientists and the parallel development of agricultural productivity were maximized. The effectiveness of station efforts, even by World War I, in increasing productivity in particular states and particular industries seems clear enough, though dairying was perhaps the most striking example.

Let me briefly elaborate this latter point. Not only in Wisconsin, but in New York, Connecticut, Minnesota, Illinois, Iowa, Vermont, and New Hampshire, dairying was actively promoted by station directors, beginning in many cases in the 1880s. Working at first with a handful of large farmers, farm editors, and farm business leaders, some directors were able by the 1890s to create a vigorous interest in this stable, year-round enterprise. A number of the more alert directors were sensitive to the economic contours of the budding dairy industry and thus aware of production and marketing problems potentially solvable by technological means. Thus at least five stations were at work in the late 1880s on a practical butter-fat test for commercial creameries. And, as we have already noted, S. M. Babcock, who proved successful in this search, had been hired by

42. Henry to A. C. True, 9 July 1898, Wisconsin File, OES.

43. When, for example, small nurserymen in North Carolina complained of inspection fees, the Experiment Station council decided that "it seems better to insist on their still paying even if there are many forced out of business. There is more danger by far from the small nurseries than from the larger ones" (Minutes of Station Council, Entry for 1 November 1897, School of Agriculture, Research Division, University Archives, North Carolina State University, Raleigh). Even in the earliest years of agitation for the creation of experiment stations and fertilizer inspection, large manufacturers of chemical fertilizers were often in favor of such programs. See B. M. Rhodes to Evan Pugh, 16 April, 23 June 1862, Pugh Papers, Penn State Collection, Pennsylvania State University.

Wisconsin because of his proven skills in milk chemistry. Once the test was described in 1890, other stations acted quickly to popularize it among the constituencies, not only publishing special bulletins, but also organizing winter short-courses in dairying with instructions in the Babcock test as a key inducement.

The economic consequences of the Babcock test extended beyond the provision of a rational method for paying producers. It served as well as a criterion for culling nonproductive animals from dairy herds and thus leading to a general upgrading of dairy stock (including the more general adoption of the Holstein-Friesian).[44] Finally, of course, the test provided a public relations argument for greater support of agricultural research and the state universities generally. (Dean Davenport could, for example, tell the chairman of his state's committee on appropriations that the Babcock test alone had been worth more to the state of Wisconsin than the cost of running the entire university throughout its history.[45]) And the Babcock test was only one among a series of technological innovations which helped reshape the American dairy industry between 1890 and 1914.[46]

It is, of course, impossible to make any categorical evaluation of the efficacy and wisdom of the investment of intellectual and capital resources by state and national governments in the stations before 1914. This is hardly a meaningful question. The problem was not, and could not, have been formulated in these terms; it is hard to imagine how the historical circumstances which gave birth to the American experiment station movement would have allowed any alternative method of subsidizing agricultural research. Nor would these resources have been diverted to other means of subsidizing pure or applied science. Neither individual units of production—the farmers—nor agriculture-related business would have considered such allocation of funds in the late nineteenth century. Only the political power and ideological primacy of both agriculture and science—in their different fashions—allowed the stations to be created.

Interest-group politics created the American experiment stations; once created, the men who staffed these new institutions, motivated by their own values and institutional needs, became an interest group of their own, forging pragmatic alliances and a research policy based on a shared interest in the growth

44. For general discussions of the Babcock test, see Lampard, *History of Dairy Industry*, and Glover, *Farm and College*. For Henry's own version of the test's background, see W. A. Henry, "Notes on the Origin of the Babcock Milk Test, Dictated March 8, 1912," typed MS, Babcock File, Library of the University of Wisconsin College of Agriculture. It would take a separate monograph to detail the story of the Babcock test and its implications for the dairying industry and the land-grant colleges. It might be noted, however, that by 1907 of some thirty-five programs in dairying at American agricultural colleges, Wisconsin had supplied instructors for Alabama, Colorado, Connecticut, Illinois, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Hampshire, North Dakota, Ohio, Oregon, Pennsylvania, South Dakota, Vermont, and Washington (*Wisconsin Agriculturalist* 31 [28 February 1907]: 2–3).

45. Davenport to George H. Rankin, 15 February 1901, Dean's Letterbooks. The ultimately ambiguous quality of such dollars-and-cents arguments is apparent.

46. It must be recalled, moreover, that the existence of such technological innovations not only had a discrete effect on productivity but served as well to stimulate the industry by changing the image of dairying and attracting general farmers to this area of specialization—a special concern of station publicists.

of productivity through the rational application of technology. The fragmented quality of American institutional life meant that the values of professionalization would—shaped into concrete institutional forms—establish themselves within this shifting intellectual and institutional landscape.[47] The station scientist's increasing commitment to professional norms was power too, power to determine a pattern of behavior which stimulated economic development and the growth of both pure science and agricultural technology.

47. This evaluation of the place of American agricultural science and scientists in the nation's social and institutional structure is in marked—and I think instructive—contrast with David Joravsky's recent and suggestive interpretation of Lysenkoian genetics in terms of Soviet realities. "Cracked Wheat," review of *The Rise and Fall of T. D. Lysenko*, by Zhores A. Medvedev, trans. by Michael Lerner, *New York Review of Books* 14 (29 January 1970): 48–52.